ANTHROPOMETRIC STUDIES OF THE HUMAN FOOT AND ANKLE [a] [b]

R. E. Isman [c]
V. T. Inman, M.D., Ph.D.[d]

Biomechanics Laboratory
University of California San Francisco Medical Center
San Francisco, Calif. 94122

ABSTRACT

A study of the talocrural (ankle) and talocalcaneal (subtalar) joints was made in order to acquire as much information as possible on the exact locations of their axes of rotation. The material used was 46 cadaver legs which had the ligamentous and capsular structures intact. The study was limited to only one of the factors that influence joint motion: the shapes of the articulating surfaces.

With a specially designed apparatus, the two axes were determined in each specimen. Then a series of measurements was made of the angles between these two axes and between these axes and various lines of reference in the shank and foot. Measurements were also made to determine the location of the axis of the talocrural joint with respect to anatomic landmarks on the leg. Finally, the perpendicular distance between the two joint axes was measured, and, in an attempt to determine the location of the axis of the talocalcaneal joint by means of anatomic landmarks, a ratio was calculated between two segments of a line assumed to extend from the most lateral point of the lateral malleolus to the most medial point of the medial malleolus.

---

[a] This study was supported by Easter Seal Research Foundation Grant N–6618. The apparatus for determination of the joint axes was designed and built under the sponsorship of Veterans Administration Contract V1005M–2075.

[b] Also published as: Isman, R. E., and Inman, V. T.: Anthropometric Studies of the Human Foot and Ankle. Biomechanics Laboratory, University of California, San Francisco and Berkeley, Technical Report 58. San Francisco, The Laboratory, May 1968. 33 pp.

[c] Student, School of Dentistry; employed under terms of Federal Work-Study Program.

[d] Director, Biomechanics Laboratory; Professor and Chairman, Department of Orthopaedic Surgery, University of California School of Medicine, San Francisco, Calif. 94122.

The measurements obtained from this sample indicate that the talocrural and talocalcaneal joints can be considered single-axis joints for purposes of bracing but that the variation in the positions of the different axes is such that they require individual determination. The use of certain skeletal landmarks to determine the axis of the talocrural joint appears to be feasible; however, no accurate method of determining the axis of the talocalcaneal joint in the living subject has emerged from this study. In addition, these data demonstrate the need to consider individual variations in any evaluation of disabilities of the ankle and foot.

I. INTRODUCTION

A study of the talocrural (ankle) and talocalcaneal (subtalar) joints was undertaken in order to acquire more accurate information than has hitherto been available regarding the locations of the axes of rotation of these joints. Some investigators (*1, 4, 5*) have stated that the talocrural joint has a changing axis as the foot proceeds from dorsiflexion to plantar flexion. Others (*2, 3, 6*) support the concept of a single axis. It is generally inferred (and definitely stated by some authors (*6, 7, 8*)) that the talocalcaneal articulation moves about a single axis.

The specific purposes of the present study were:

1. to determine whether the talocrural and talocalcaneal joints are actually single-axis joints, or, if they are found to have two or more axes, to determine whether these axes are sufficiently close to single axes to permit the use of single-axis joints in the construction of braces;
2. to determine easily identifiable skeletal landmarks which might be used for the location of the anatomic axes and for the alignment of braces;
3. to accumulate data regarding individual variations and the extreme values in the positions of the axes; and
4. to acquire a sufficient number of measurements to allow calculation of possible correlations.

This study was performed upon legs of cadavers obtained from the Department of Anatomy at the conclusion of instruction in gross anatomy. Many feet were undissected and others were partially dissected. All had the ligamentous and capsular structures intact. Since most of them were from older persons, the sample was not truly representative of the population. No specimens, however, showed gross arthritic changes in the articular cartilaginous surfaces of the joints.

The legs of the cadavers were cut transversely (through the tibia and fibula) at a point approximating the junction of the middle and distal thirds of the tibia. The tissues surrounding the talocrural and talocalcaneal joints were dissected away, including all capsular and ligamentous structures. This was necessary to permit unrestricted movement of the trochlea in the mortice and to locate the point of minimal motion on either side of the talus. Manual pressure of the talus into the mortice insured congruence of the articular surfaces.

There are many factors that influence joint motion, such as the shape of articular surfaces; constraints due to ligaments, capsules, and tendons; and forces transmitted through the joint, which are important because of the elasticity of the tissues involved, particularly cartilage. Since this study was confined to cadaver specimens and since all constraining tissues were removed to facilitate observation of joint motion, our results reflect only the effects of the first factor mentioned above (the shape of articular surfaces).

In most specimens, the curvature of the upper surface of the trochlea, when measured in a plane parallel to the malleolar facets, is not an arc of a circle, but tends to be elliptical. This finding confirms the observations of Barnett and Napier (*1*). However, since the planes of the malleolar facets were only rarely found to be normal to the experimentally determined axis of the ankle joint, this elliptical shape does not necessarily exclude the possibility of a single axis. The techniques employed here were sufficiently gross that a precise location of the axis was impossible. Even so, the anteroposterior excursion of the steel rod was never more than 1 to 3 mm. when the joint was moved through its entire range.

The techniques employed in the location of the axis of the talocalcaneal joint proved to be somewhat inadequate to allow an unequivocal statement that this joint has only a single axis. However, the axis of rotation, as determined, usually maintained complete congruency of the articular surfaces when the joint was moved through its entire range.

II. LOCATION OF ROTATIONAL AXES

A. Talocrural Joint (Fig. 1 and 2)

The axis of rotation of the talocrural joint was established in the following manner: The tibia was securely clamped in an axis-locating device with several movable arms which made it possible to turn the tibia to any position (Fig. 3). The fibula remained attached to the tibia by the interosseous membrane. The disarticulated talus was then held firmly by hand against the inferior articular surfaces of the tibia and fibula and rotated. By manipulating the various arms of the device, the tibia and fibula, with the talus held firmly against them, could be positioned so that the rotation of the talus could be observed under cross-hairs (Fig. 4).

The arms of the device were positioned so that the point at which the

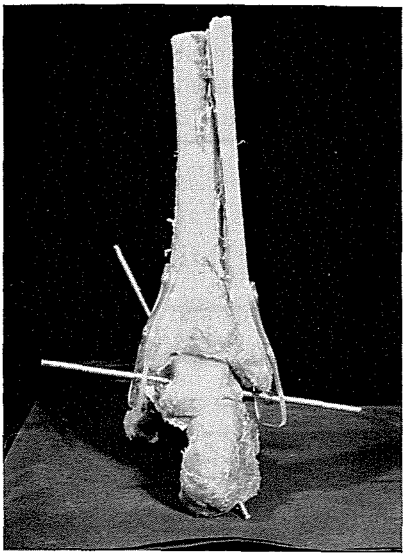


FIGURE 1.—Posterior view of right foot and lower leg, showing positions of axes of talocrural and talocalcaneal joints.

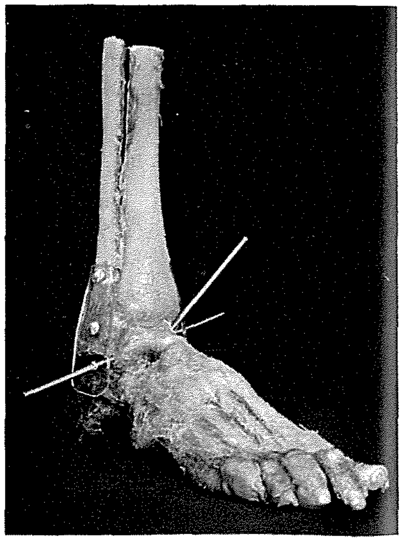


FIGURE 2.—Anterolateral view of right foot and lower leg, showing positions of axes of talocrural and talocalcaneal joints.

least amount of displacement of the talus occurred was observed under the cross-hairs. This point was then marked on the talus; it established one point of exit for the axis of the talocrural joint. The entire apparatus was then turned over and the same procedure was followed to locate the point of minimum rotation on the opposite side of the talus. The tibia and fibula were unclamped, and the talus was clamped in a position that allowed a 3-mm. (1/8-in.) hole to be drilled through it to connect the marks previously placed on its lateral and medial surfaces.

When the talus was placed against the tibia and fibula, it was found that the axis of rotation passed distal to the tips of the tibial and fibular malleoli. In order to make the desired measurements, the following method was employed. Strips of clear Plexidur (a modified acrylic) 7.6 cm. by 16 mm. by less than 2 mm. were heated with a hot air blower until flexible, and were molded over the malleoli to act as extensions; when cooled they retained their molded shape. A strip was screwed to one malleolus; the talus was then held in place tightly (as was done in locating the axis) in an intermediate position between dorsiflexion and plantar flexion, and the axis was extended by drilling a 3-mm. hole through the plastic strip. The same procedure was repeated for the opposite side. Finally, a steel pin, 3 mm. in diameter and 15 cm. (6 in.) long, was inserted through the holes in the plastic strips and the talus

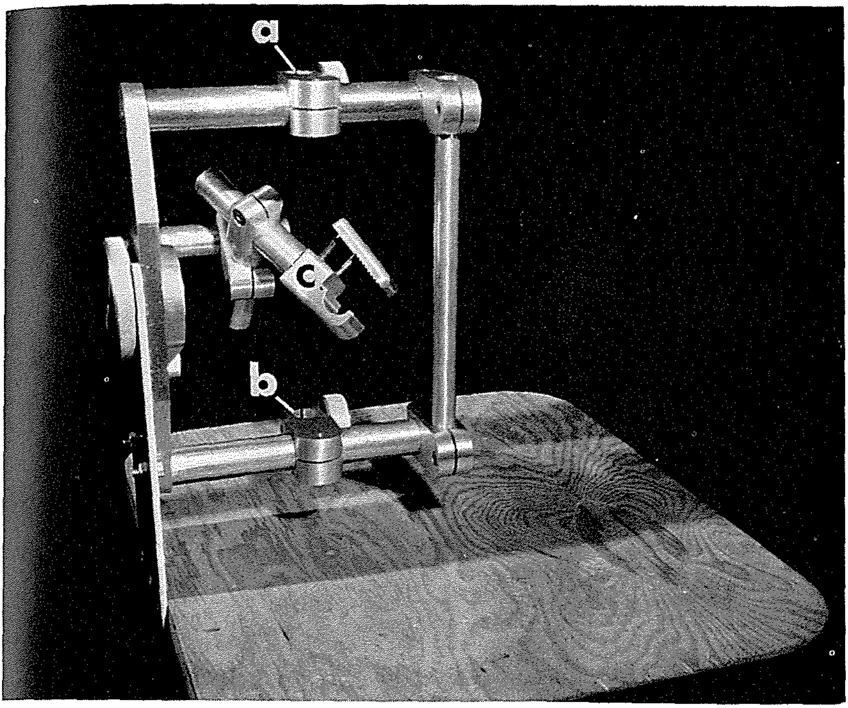


FIGURE 3.—Axis-locating device for talocrural joint. Holes *a* and *b* can hold cross-hairs or a drill guide. Clamp (*c*) holds tibia securely and is adjustable so that any point on tibia may be viewed under cross-hairs. Frame can be inverted so that point *a* is at point *b* and vice-versa.

to represent the axis of rotation of the talocrural joint (see Fig. 1 and 2). The accuracy of the axis could be immediately determined by rotating the talus and observing the degree of contact of the apposing articular surfaces.

B. Talocalcaneal Joint (Fig. 1 and 2)

The pin through the talus representing the axis of rotation of the talocrural joint was removed. The disarticulated talus was held firmly against the calcaneus and rotated. The point on the superior aspect of the talus that rotated least was located by eye and was assumed to indicate the superior exit of the talocalcaneal axis. This procedure was tried for the inferior exit by holding the talus stationary and rotating the calcaneus, but the result was found to be quite inaccurate. Instead, the following method (see Fig. 5) was used to determine the inferior exit of the axis: A small piece of wire was embedded in the cartilage of the posterior articular facet of the calcaneus (where it articulates with the

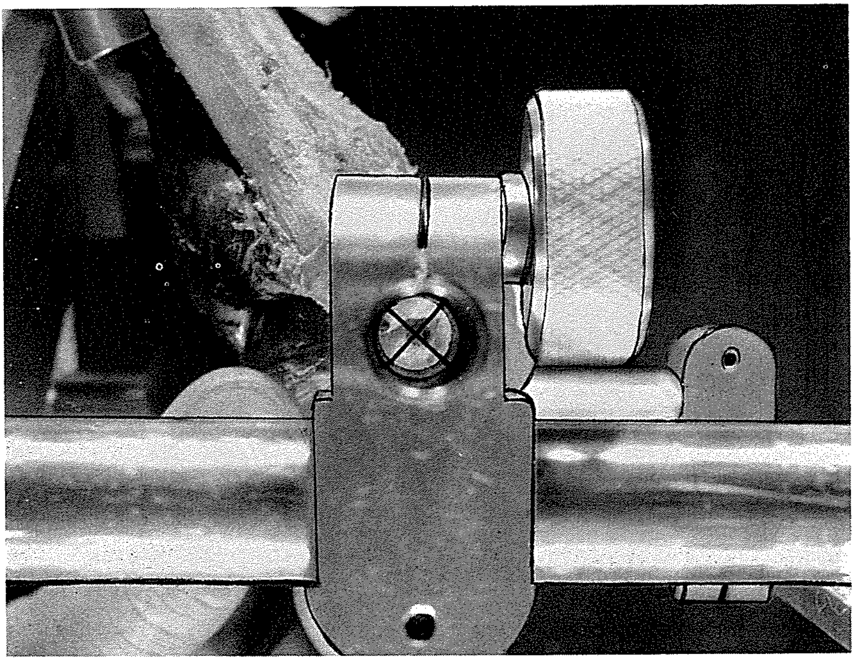


FIGURE 4.—Talus held firmly by hand against mortice of tibia and fibula. Dark spot under cross-hairs is hole, previously drilled through talus, locating in this case lateral exit of talocrural-joint axis.

talus) and allowed to protrude 1 to 2 mm. The talus was then pressed firmly against the calcaneus and rotated; this caused the wire to inscribe an arc on the articular cartilage of the talus. A compass was used to approximate the center of the inscribed arc. This center established the point marking the inferior exit of the axis of the talocalcaneal joint on the talus. The talus was clamped so that a hole representing the axis could be drilled through the two points; the talus was then held tightly against the calcaneus and the hole representing the axis was extended through the calcaneus.

III. MEASUREMENTS

Several measurements were taken in order to establish the angles between the axes of the talocrural and talocalcaneal joints and various reference planes. Also, the location of the talocrural axis with respect to fairly reliable anatomic landmarks was established. For measurements (C, D, E) and (G-Q) the foot was placed flat on a table with the tibia at a right angle to the table. In the following descriptions of measure-

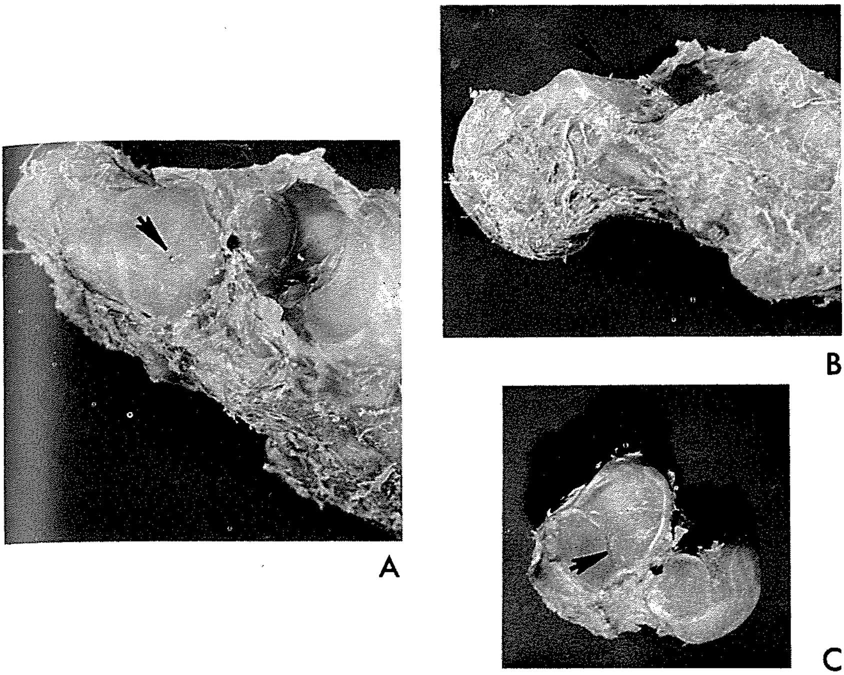


FIGURE 5.—Method used to determine inferior exit of axis of talocalcaneal joint on talus. *A,* superior and *B,* lateral view of right calcaneus with arrow showing wire embedded in posterior articular facet. *C,* inferior aspect of right talus, showing arc inscribed by wire embedded in articular cartilage of calcaneus.

ments, *horizontal* is used to mean the plane of the table surface and *vertical,* a plane at a right angle to the horizontal.

A. Angle Between Inferior Articular Surface of Tibia and Long Axis of Tibia (Fig. 6)

The long axis of the tibia was determined by locating points at the superior and inferior ends of the anterior surface of the tibial specimen midway between the medial and lateral surfaces and was marked by drilling small holes at these points. The specimen was then laid on a sheet of paper, and a line was drawn through the points and extended onto the paper. The plane of the inferior articular surface of the tibia was approximated by laying a straightedge across the upper edge of this surface and roughly parallel to it. Perpendiculars were dropped from the ends of the straightedge to the paper, the points were connected by a line, and the angle this line made with the long axis of the tibia was measured with a protractor.

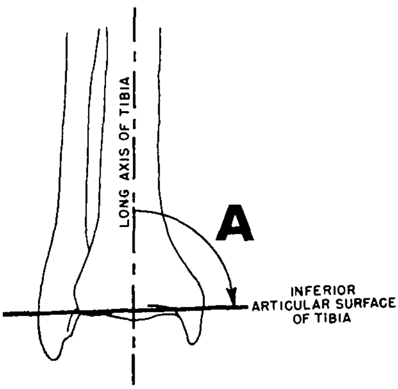


FIGURE 6

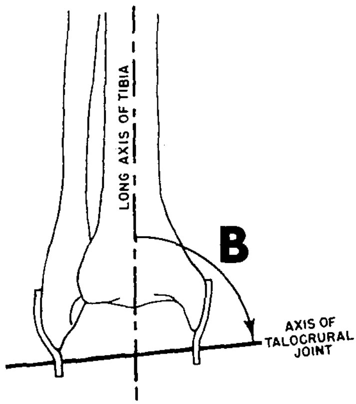


FIGURE 7

B. Angle Between Axis of Talocrural Joint and Long Axis of Tibia (Fig. 7)

The long axis of the tibia was established as in (A) above. Perpendiculars were dropped from the ends of the steel pin representing the axis of rotation of the talocrural joint and points were marked on the paper. These points were connected by a line and the angle this line made with the long axis of the tibia was measured with a protractor.

C. Angle Between Axis of Talocrural Joint and Midline of Foot, Projected on Horizontal Plane (Fig. 8)

The midline of the foot was taken to be a line drawn from a point midway between the second and third toes to the midpoint of the calcaneus. This line was established with the plantar surface of the foot on a piece of paper. With use of a square, perpendiculars from the ends of the steel pin representing the axis of the talocrural joint were dropped to the paper and these end points were connected by a line; the angle between this line and the midline of the foot was measured with a protractor.

D. Angle Between Axis of Talocalcaneal Joint and Midline of Foot, Projected on Horizontal Plane (Fig. 9)

The same procedure was used as in (C), except that the perpendiculars were dropped from the ends of the pin representing the talocalcaneal joint.

E. Angle Between Axes of Talocrural and Talocalcaneal Joints, Projected on Horizontal Plane (Fig. 10)

The positions of the two axes were projected on the paper as above,

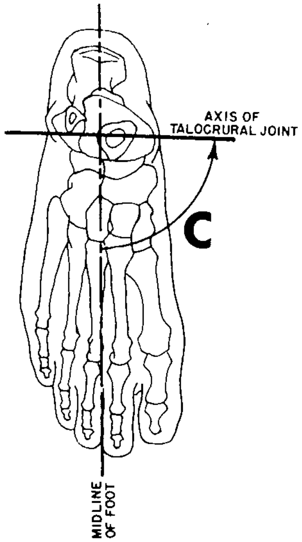


FIGURE 8

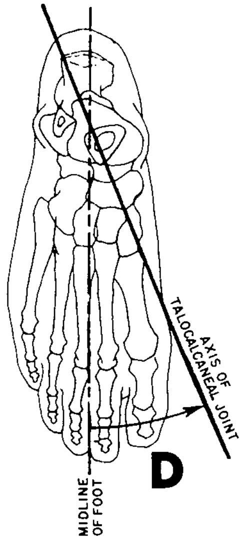


FIGURE 9

and the angle between the projected axes was measured with a protractor.

F. True Angle Between Axes of Talocrural and Talocalcaneal Joints (Fig. 11)

The talus was disarticulated from the foot and leg, with the pins representing the axes of both joints left in place, and was then placed over

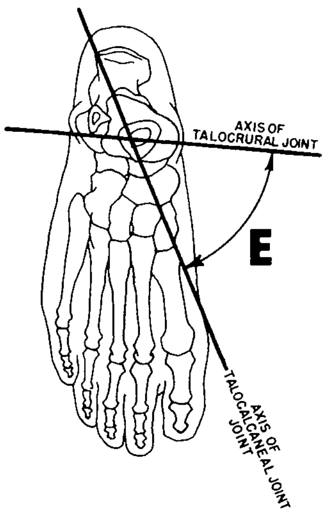


FIGURE 10

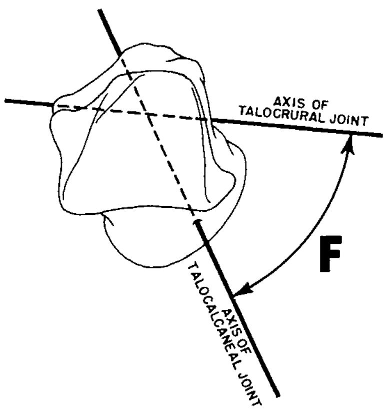


FIGURE 11

the open end of a cardboard box, with the protruding pins resting on the edges of the box. The positions of the pins on the box edges were marked, straightedges were placed across the marks, and the angle between the straightedges was measured with a protractor.

G. Angle Between Axis of Talocalcaneal Joint and Horizontal Plane (Fig. 12)

This was measured in the following manner: The vertical distances were measured from the ends of the steel pin representing the axis to the table, and the difference between the two heights was noted. This difference forms one side of a right triangle, the hypotenuse of which is the length of the steel pin, or 15 cm. (6 in.). Thus, the sine of the desired angle is obtained with use of the equation,

$$\text{sine } G = \frac{l}{h_2 - h_1}$$

where G = angle between axis of subtalar joint and the horizontal

l = length of steel pin

h_2 = distance from anterior end of pin to the horizontal

h_1 = distance from posterior end of pin to the horizontal

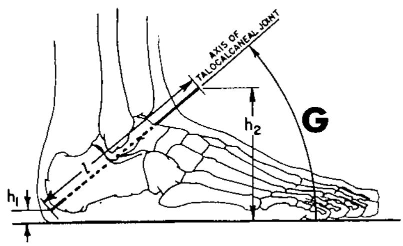


FIGURE 12

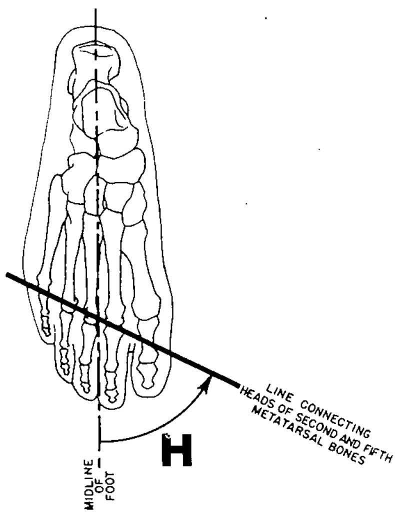


FIGURE 13

H. Angle Between Line Connecting Heads of Second and Fifth Metatarsal Bones and Midline of Foot (Fig. 13)

This was measured by placing the foot on a piece of paper, locating the midline of the foot as previously described, and using a square held against the heads of the second and fifth metatarsal bones to drop perpendiculars to the paper. The two points were connected by a line and the angle between this line and midline of the foot was measured with a protractor.

I.—P. Location of Axis of Talocrural Joint with Respect to Anatomic Landmarks on Leg (Fig. 14)

Vertical lines and horizontal (anteroposterior) lines were drawn through (1) the distal tip of the lateral malleolus (I and J), (2) the most lateral point of the lateral malleolus (K and L), (3) the distal tip of the medial malleolus (M and N), and (4) the most medial point of the medial malleolus (O and P). Perpendicular distances were measured to these lines from the points where the steel pin representing the axis of the talocrural joint pierced the plastic extensions. These distances were recorded as distal to (+), proximal to (−), anterior to (+), and posterior to (−) the four lines described above.

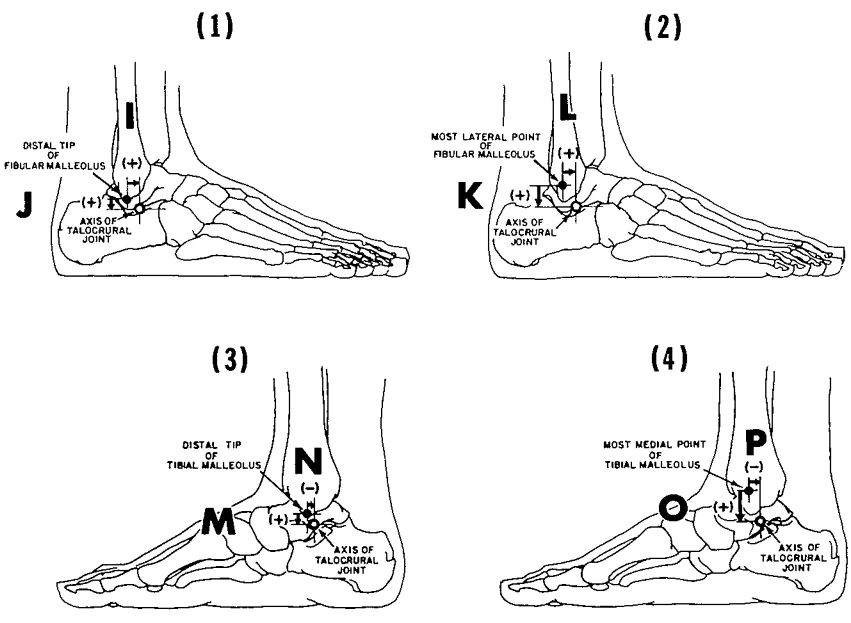


FIGURE 14

Q. Perpendicular Distance Between Axes of Talocrural and Talocalcaneal Joints (Fig. 15)

This measurement was made by sighting down the axis of the talocrural joint (which in all specimens but one was superior to that of the talocalcaneal joint), so as to view it as a point, and measuring the perpendicular distance from this point to the pin representing the axis of the talocalcaneal joint. A clear plastic millimeter rule was used.

R. Ratio w:W (Fig. 16)

In an attempt to determine a method for estimating, in the living subject, the location of the talocalcaneal axis as it passes through the talus, the ratio w:W was calculated, where W = the distance between the most lateral point of the lateral malleolus and the most medial point of the medial malleolus, and w = the distance from the most lateral point of the lateral malleolus to the point at which W crosses the axis of the talocalcaneal joint.

IV. PRESENTATION OF DATA AND CONCLUSIONS

All measurements taken from this series of 46 cadaver legs are given in Figures 17–21. The mean ($\bar{x}$), range of values (R), and standard deviation (S.D.) are also presented for each category. The columns are designated A through R. These letters correspond with the descriptions of the measurements in Section III and with Figures 22–35, which display pictorially the precise sites of the measurements.

As expected, large individual variations occurred in all measurements. The greatest variation occurred in the angle between the axis of the talo-

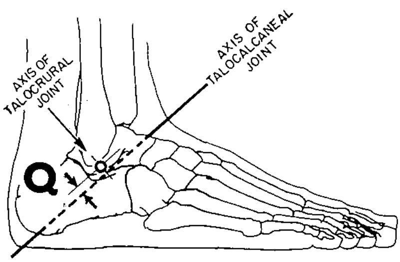


FIGURE 15

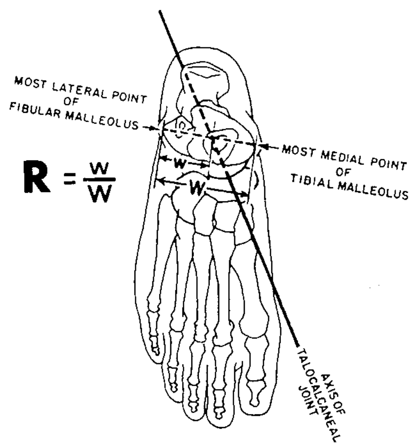


FIGURE 16

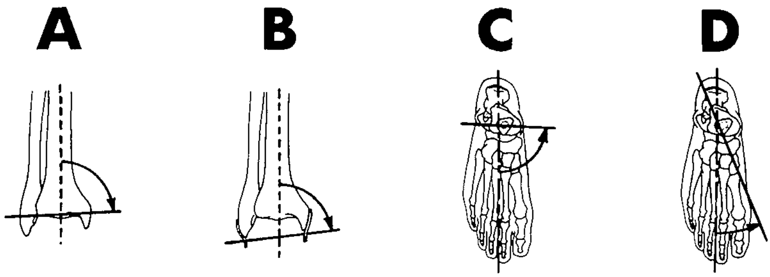
calcaneal joint and the long axis of the foot (Fig. 25). A part of this variation was due to the amount of pronation or supination of the individual foot and does not truly represent the anatomic variation of the talocalcaneal axis as related to the articulated talus and calcaneus (isolated from the remainder of the foot).

In an attempt to determine whether our sample was sufficiently large to represent the population adequately, distribution curves were prepared. They provide a rough approximation of a normal distribution, but it is obvious that a larger sample, which we are planning to secure, would be more meaningful, provided that the sample is representative of the total population.

While the variations in individual measurements appear to be random, it was hoped that some relationship would be found between them that would indicate interdependence. Coefficients of correlation were calculated between pairs of 10 selected measurements, but no significant correlation was found to exist. Further correlations will be made when a larger number of measurements is available.

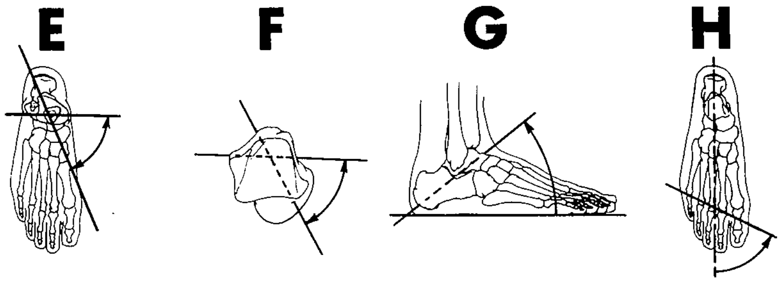
The measurements obtained from this sample indicate that the talocrural and talocalcaneal joints can be considered single-axis joints for purposes of bracing but that the variation in the positions of the different axes is such that they require individual determination. The use of certain skeletal landmarks to determine the axis of the talocrural joint appears to be feasible; however, no accurate method of determining the axis of the talocalcaneal joint in the living subject has emerged from this study. In addition, these data demonstrate the need to consider individual variations in any evaluation of disabilities of the ankle and foot.

It is to be expected that these skeletal variations will influence the activity of the controlling musculature and will affect the behavior of the entire functional unit during locomotion.



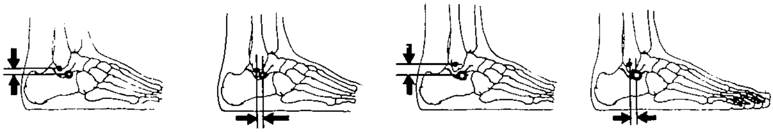
Specimen (no.)	A (degrees)	B (degrees)	C (degrees)	D (degrees)
1	86	78	80	25
2	87	83	84	25
3	89	86	82	28
4	85	71	82	16
5	86	81	92	35
6	90	86	88	23
7	75	80	78	23
8	86	85	90	27
9	89	80	76	23
10	82	82	92	28
11	84	78	85	20
12	86	80	76	30
13	86	88	76	4
14	86	81	90	38
15	84	78	84	18
16	84	72	90	43
17	84	79	80	18
18	86	77	76	13
19	82	78	82	36
20	80	78	96	24
21	86	80	85	10
22	86	86	88	23
23	87	78	88	31
24	89	80	79	24
25	80	74	92	14
26	90	80	95	35
27	80	68	84	11
28	83	82	73	33
29	92	82	70	7
30	86	77	86	29
31	88	80	82	32
32	83	74	90	14
33	84	80	78	12
34	82	80	84	47
35	83	75	74	12
36	88	84	75	10
37	88	83	90	19
38	85	77	84	26
39	81	78	86	16
40	85	84	69	10
41	78	78	86	12
42	89	80	92	18
43	83	66	87	14
44	96	83	87	24
45	87	74	99	47
46	91	86	86	15
$\bar{x}$	85	80	84	23
S.D.	±5	±4	±7	±11
R	75 to 96	68 to 88	69 to 99	4 to 47
	(degrees)	(degrees)	(degrees)	(degrees)

FIGURE 17



Specimen (no.)	E (degrees)	F (degrees)	G (degrees)	H (degrees)
1	56	54	34	60
2	58	56	28	60
3	54	54	28	62
4	66	60	48	62
5	57	55	40	62
6	65	64	46	60
7	55	65	48	60
8	63	64	32	58
9	53	54	40	58
10	64	62	31	66
11	66	58	52	67
12	47	52	44	58
13	72	75	52	71
14	52	53	30	56
15	66	75	41	64
16	46	41	40	59
17	61	65	38	62
18	63	65	32	62
19	46	52	54	54
20	72	68	42	62
21	75	74	44	63
22	65	63	37	54
23	57	57	42	54
24	56	57	33	59
25	77	67	48	72
26	60	60	54	54
27	73	65	50	65
28	40	61	68	72
29	64	66	33	67
30	57	61	50	61
31	50	52	20	59
32	77	70	34	64
33	65	65	41	67
34	37	49	57	69
35	62	66	40	67
36	65	62	36	64
37	70	68	38	62
38	58	65	36	56
39	70	60	46	62
40	59	59	42	72
41	73	71	39	62
42	74	68	46	56
43	73	68	37	69
44	63	59	32	54
45	52	55	38	57
46	72	72	23	62
$\bar{x}$	61	62	41	62
S.D.	±8	±7	±9	±6
R	37 to 77	41 to 75	20 to 68	54 to 72
	(degrees)	(degrees)	(degrees)	(degrees)

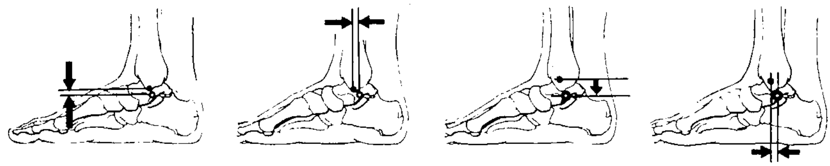
FIGURE 18



Specimen (no.)	I (mm)	J (mm)	K (mm)	L (mm)
1	3	9	11	10
2	0	6	6	9
3	-2	7	9	10
4	5	8	14	8
5	6	7	12	11
6	0	10	8	8
7	3	6	12	12
8	0	9	7	9
9	0	7	15	9
10	0	13	18	16
11	6	8	13	7
12	2	8	11	10
13	2	9	9	9
14	7	16	19	14
15	3	13	12	13
16	-2	10	12	9
17	12	15	19	8
18	2	13	9	15
19	6	7	11	8
20	0	20	4	23
21	7	8	5	9
22	0	9	13	11
23	2	8	13	11
24	7	-1	17	10
25	2	7	6	14
26	5	12	15	10
27	6	7	18	6
28	5	2	12	6
29	2	10	13	11
30	1	11	7	4
31	3	1	14	3
32	6	8	15	10
33	1	12	11	20
34	1	0	15	9
35	2	15	14	19
36	0	19	10	21
37	0	11	5	11
38	4	-2	16	9
39	3	10	10	7
40	3	13	9	9
41	1	12	11	15
42	4	2	14	7
43	2	4	13	16
44	3	-8	12	9
45	4	5	12	7
46	-2	12	7	13
$\bar{x}$	3	8	12	11
S.D.	±3	±5	±4	±4
R	-2 to +12	-8 to +20	4 to 19	3 to 23
	(mm)	(mm)	(mm)	(mm)

Figure 19

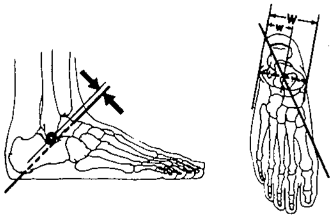
	M	N	O	P



Specimen (no.)	M (mm)	N (mm)	O (mm)	P (mm)
1	6	0	18	-13
2	4	0	15	2
3	11	-5	19	8
4	-1	3	11	2
5	5	-4	16	-6
6	6	-3	16	0
7	12	4	21	-2
8	10	-6	19	-7
9	4	0	14	-2
10	7	-1	19	0
11	6	-3	18	-5
12	6	2	18	1
13	10	-4	21	2
14	3	-3	16	-10
15	3	-7	13	-5
16	0	0	14	1
17	5	-4	18	0
18	3	-5	15	-5
19	4	8	13	5
20	4	-2	17	0
21	7	1	16	0
22	8	0	11	-6
23	3	7	23	3
24	2	-1	20	-4
25	1	-6	10	6
26	3	-6	12	-2
27	0	-3	10	-3
28	1	-3	15	-2
29	7	-9	20	0
30	3	-3	13	-6
31	1	-5	11	-1
32	6	0	15	10
33	1	-4	7	4
34	5	1	16	-5
35	4	-5	10	0
36	13	0	25	13
37	0	7	11	9
38	1	5	15	0
39	2	0	11	2
40	8	3	23	-1
41	4	3	19	-2
42	6	0	18	-3
43	5	0	15	-7
44	2	7	12	-6
45	4	6	13	-1
46	6	5	16	4
$\bar{x}$	5	-1	16	-1
S.D.	±3	±4	±4	±5
R	-1 to +13	-9 to +8	7 to 25	-13 to +13
	(mm)	(mm)	(mm)	(mm)

FIGURE 20

Q R



Specimen (no.)	(mm)	(w:W)
1	2	.54
2	7	.49
3	7	.45
4	10	.54
5	6	.44
6	3	.53
7	2	.41
8	5	.53
9	4	.50
10	5	.51
11	6	.61
12	3	.47
13	8	.50
14	6	.48
15	2	.59
16	9	.50
17	4	.66
18	5	.51
19	3	.47
20	8	.56
21	3	.61
22	4	.60
23	5	.58
24	3	.50
25	6	.55
26	7	.59
27	3	.60
28	8	.43
29	4	.56
30	6	.60
31	2	.52
32	3	.63
33	6	.53
34	7	.50
35	12	.47
36	-5	.57
37	6	.58
38	5	.54
39	5	.64
40	3	.54
41	4	.67
42	0	.63
43	0	.65
44	7	.63
45	0	.50
46	0	.55
$\bar{x}$	5	.54
S.D.	±3	±.06
R	-5 to +12	.41 to .67
	(mm)	(w:W)

FIGURE 21

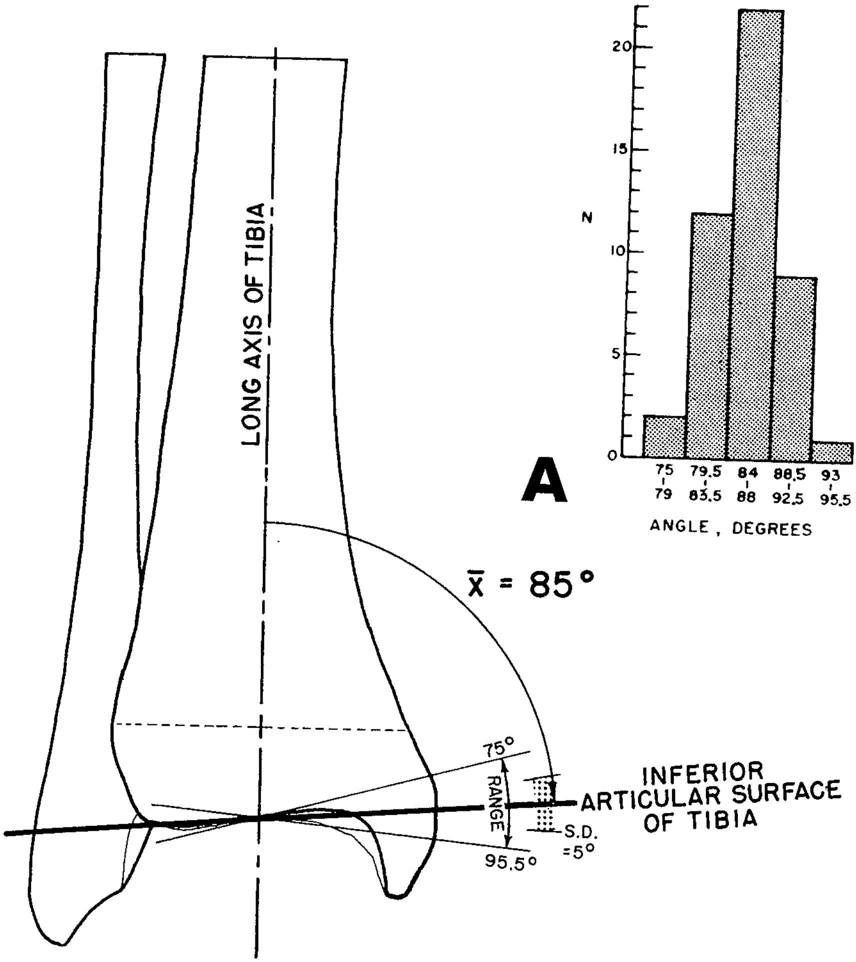


FIGURE 22.—Angle between inferior articular surface of tibia and long axis of tibia.

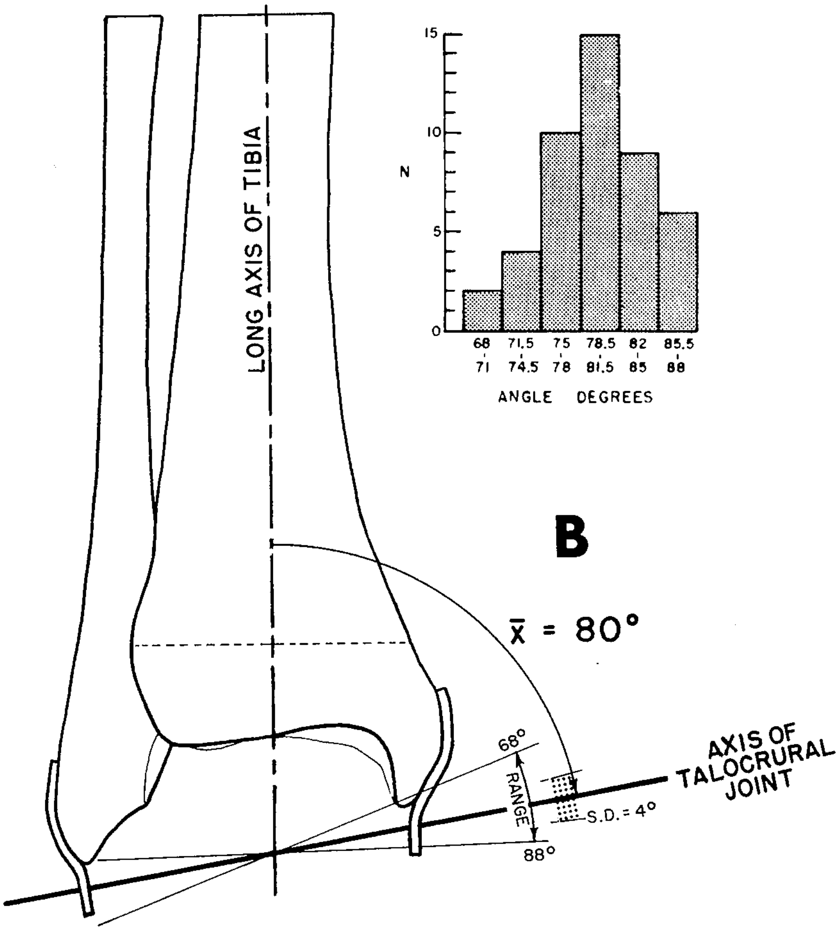


FIGURE 23.—Angle between axis of talocrural joint and long axis of tibia.

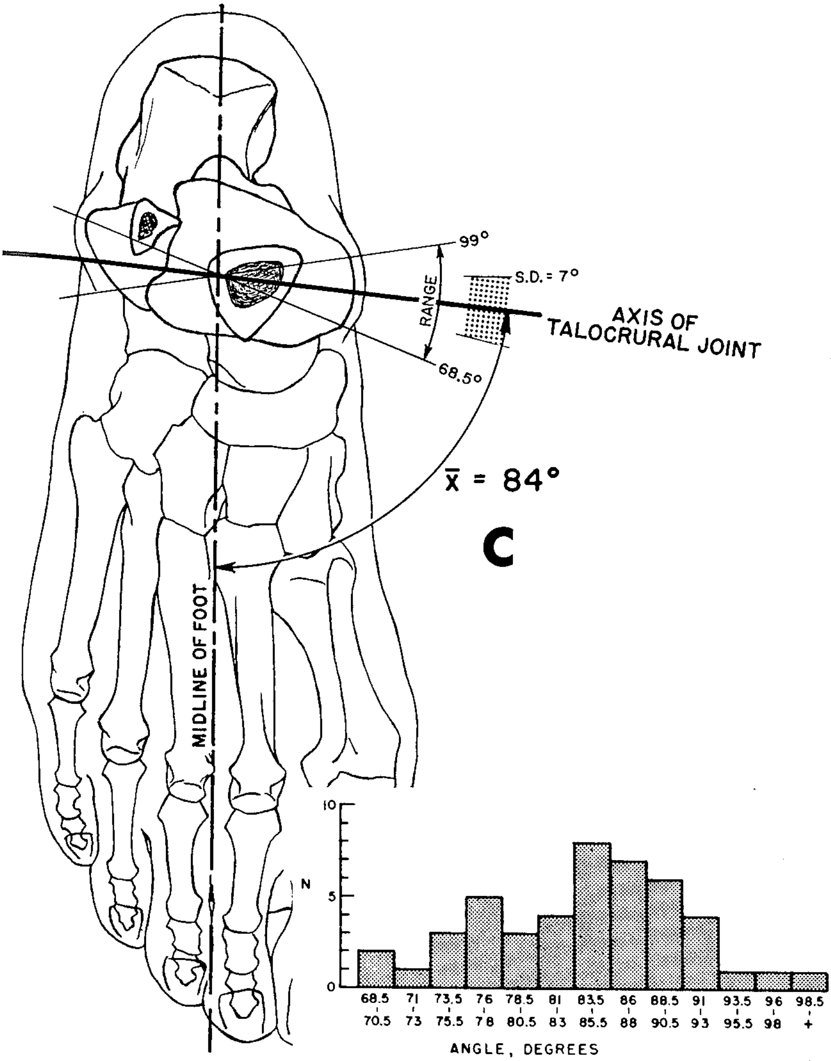


FIGURE 24.—Angle between axis of talocrural joint and midline of foot, projected on horizontal plane.

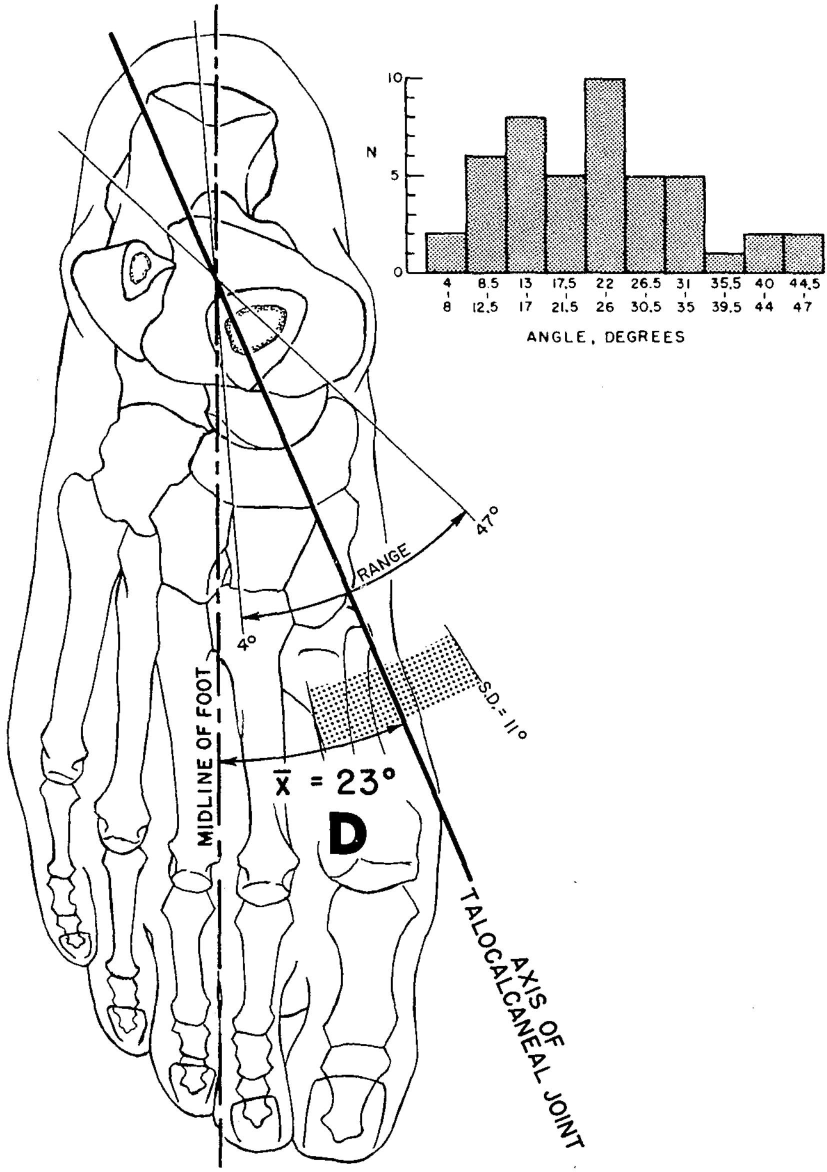


FIGURE 25.—Angle between axis of talocalcaneal joint and midline of foot, projected on horizontal plane.

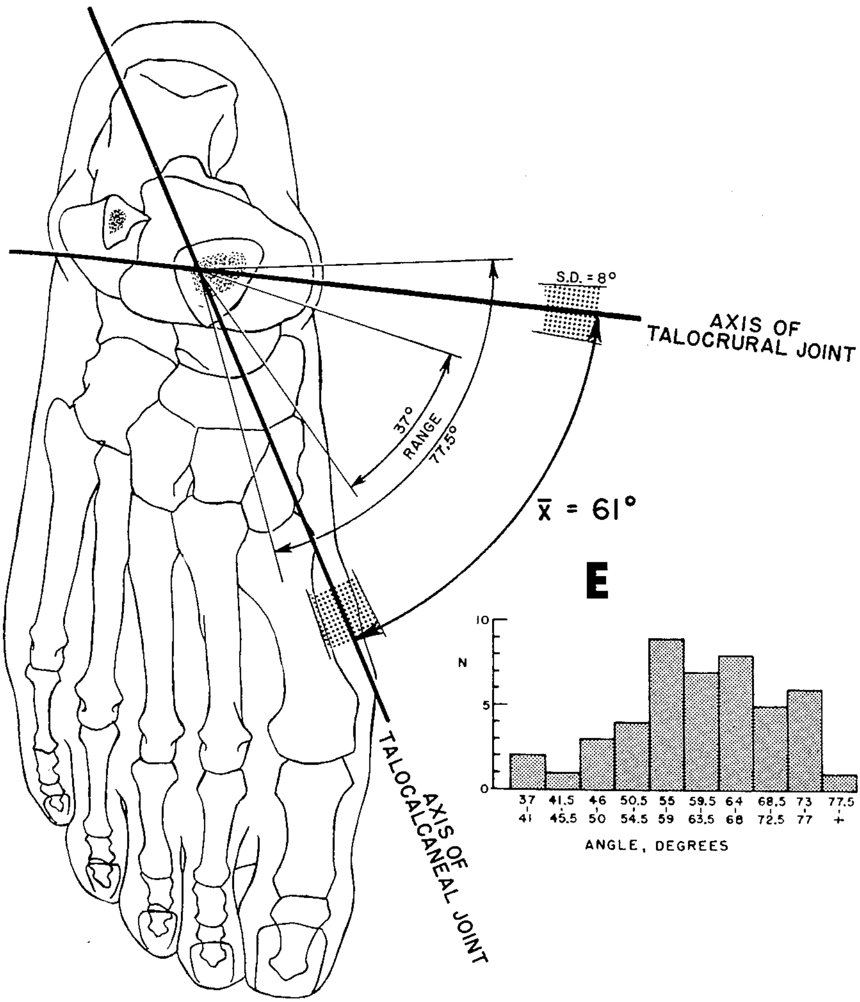


FIGURE 26.—Angle between axes of talocrural and talocalcaneal joints, projected on horizontal plane.

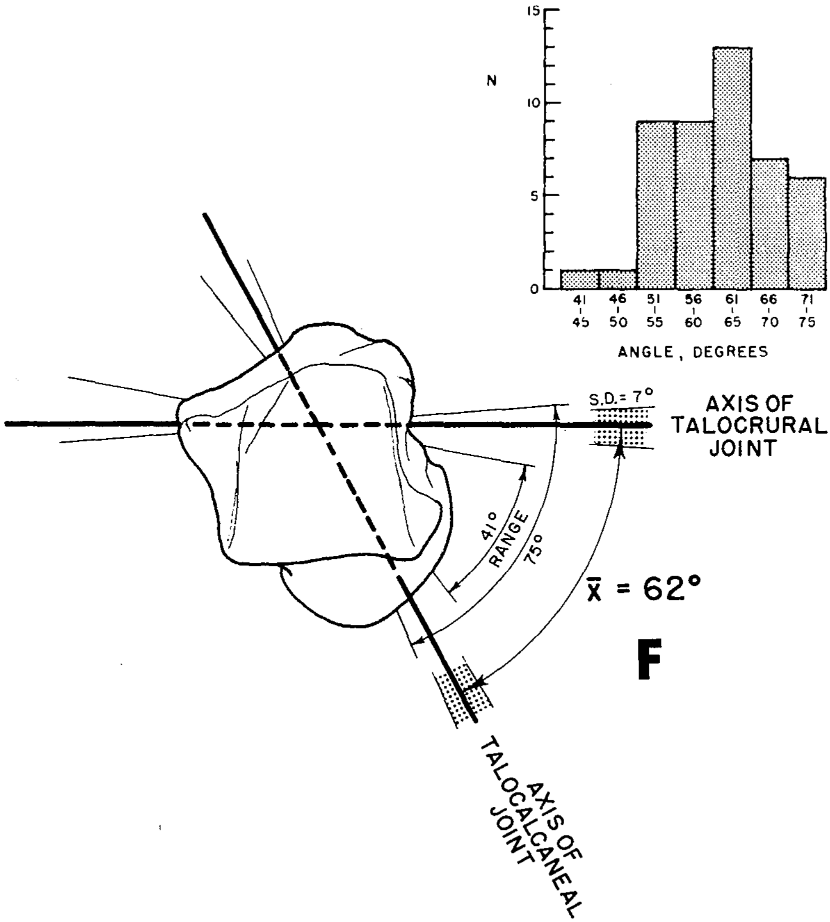


FIGURE 27.—True angle between axes of talocrural and talocalcaneal joints.

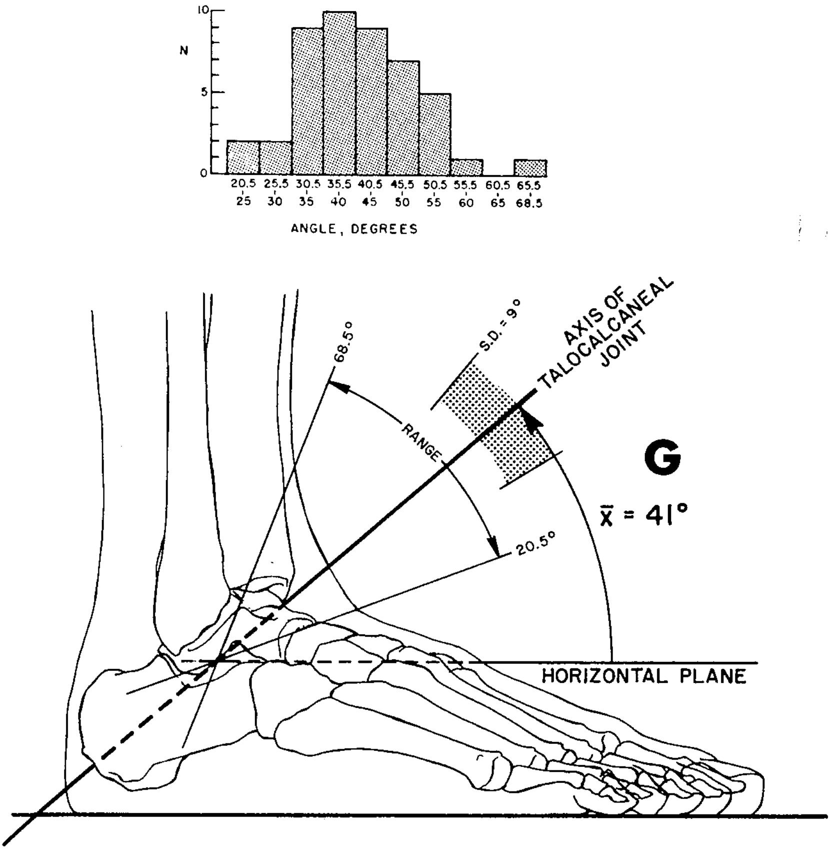


FIGURE 28.—Angle between axis of talocalcaneal joint and horizontal plane.

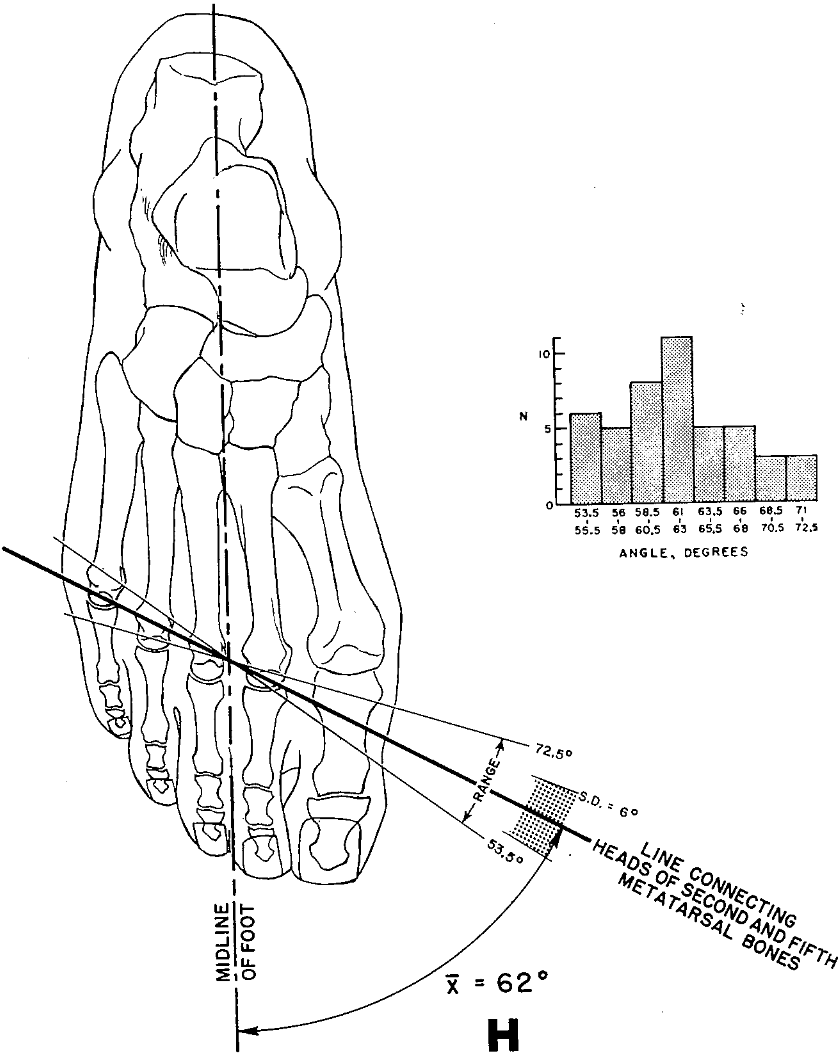


FIGURE 29.—Angle between line connecting heads of second and fifth metatarsal bones and midline of foot.

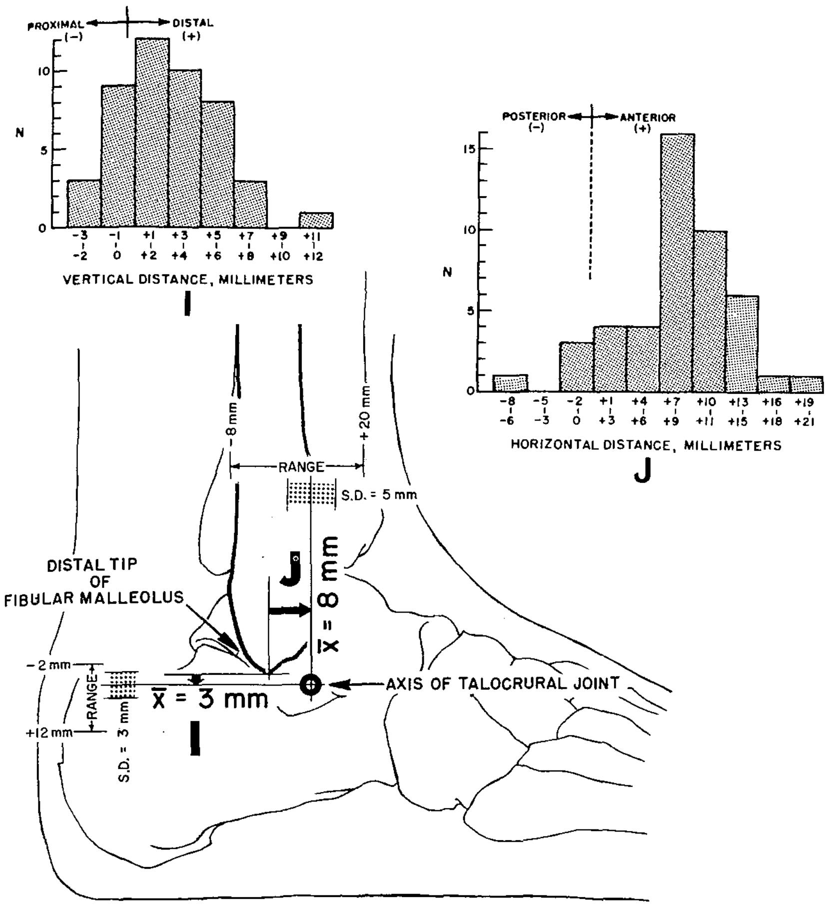


FIGURE 30.—Location of axis of talocrural joint with respect to distal tip of lateral malleolus.

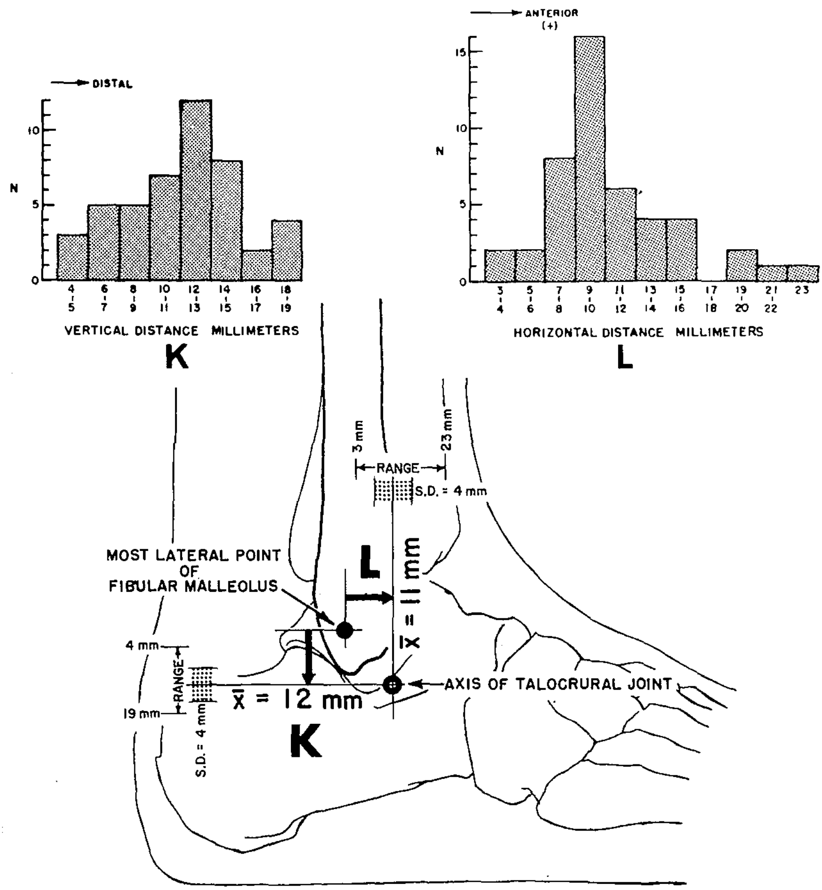


FIGURE 31.—Location of axis of talocrural joint with respect to most lateral point of lateral malleolus.

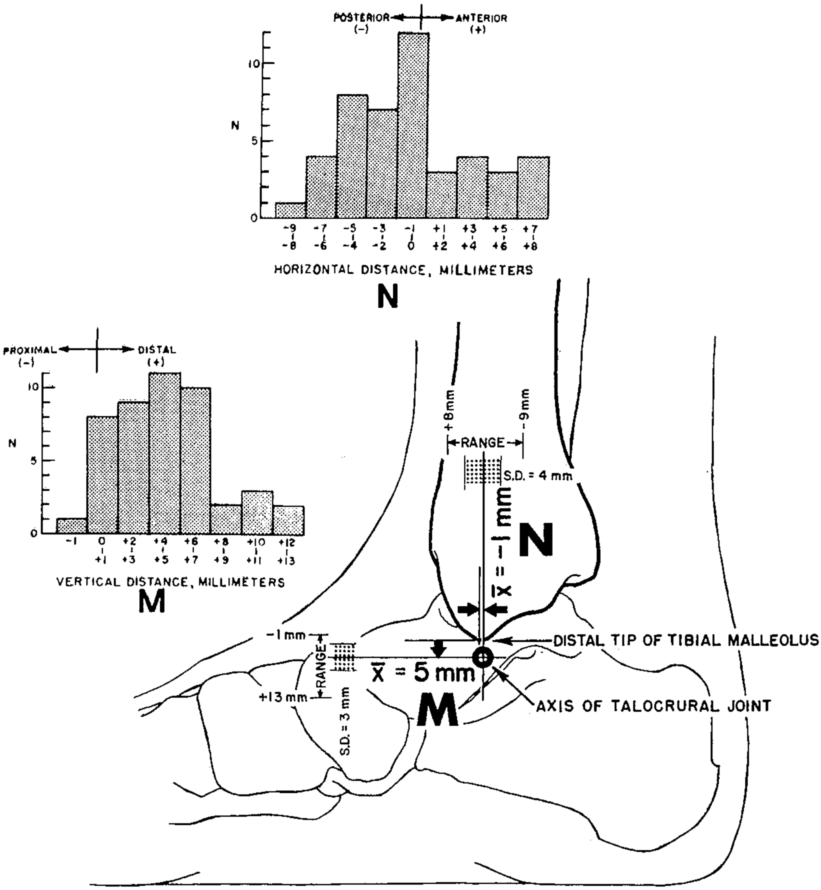


FIGURE 32.—Location of axis of talocrural joint with respect to distal tip of medial malleolus.

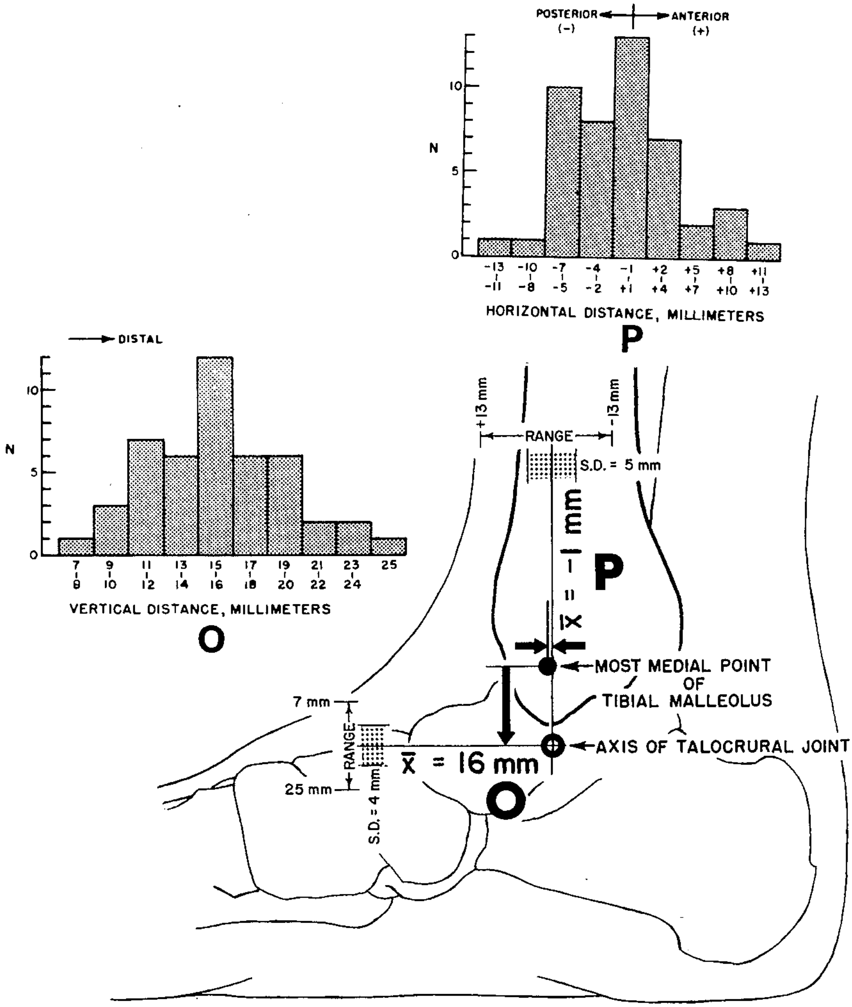


FIGURE 33.—Location of axis of talocrural joint with respect to most medial point of medial malleolus.

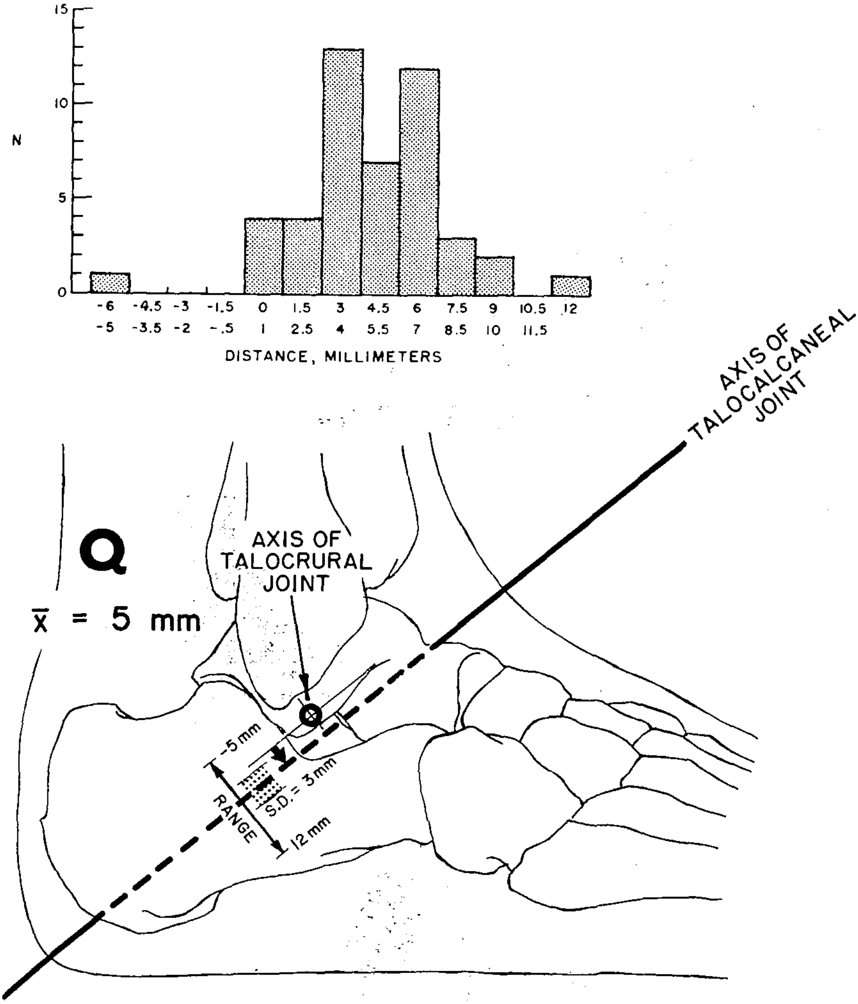


FIGURE 34.—Perpendicular distance between axes of talocrural and talocalcaneal joints.

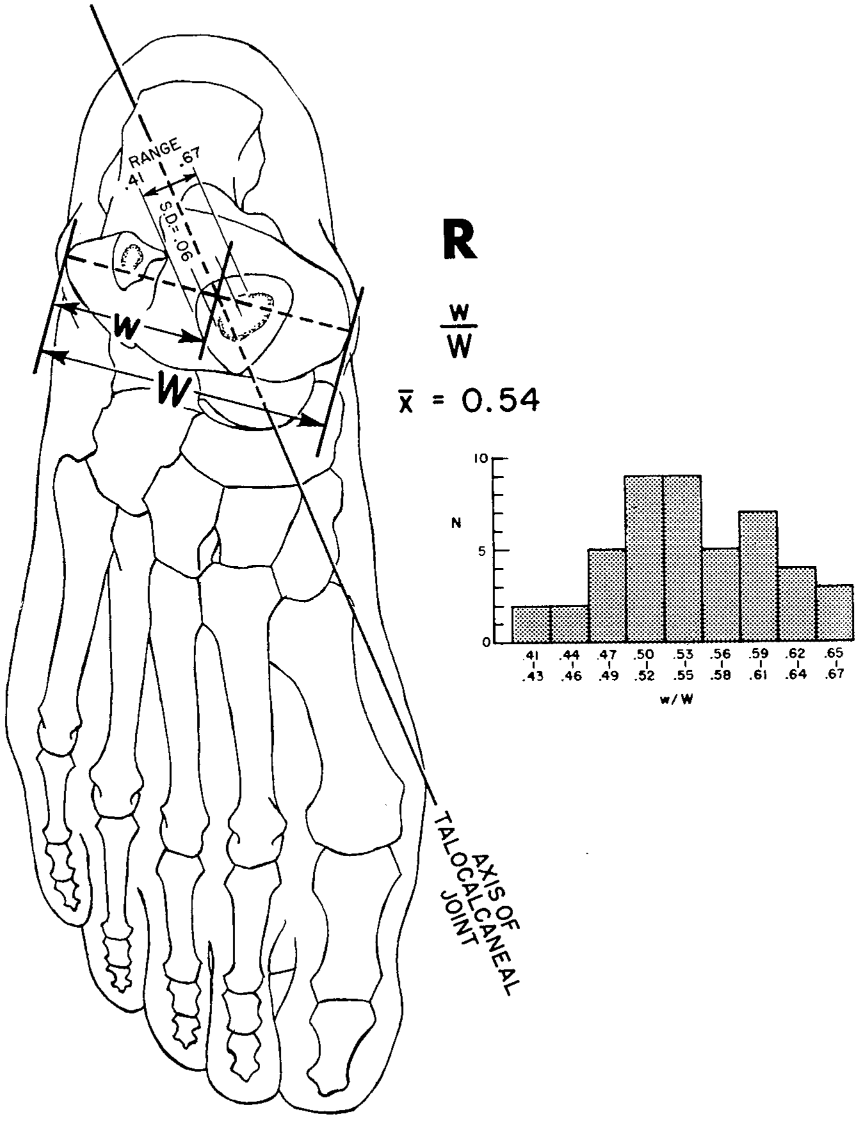


FIGURE 35.—Ratio w:W (see text for explanation).

REFERENCES

1. BARNETT, C. H., and J. R. NAPIER: The Axis of Rotation at the Ankle Joint in Man. J. Anat., 86: 1–8, 1952.
2. BRAUS, H.: Anatomie des Menschen. Vol. 1: Bewegungsapparat. Berlin, Springer, 1921. P. 621.
3. CUNNINGHAM, D. J.: Textbook of Anatomy. Edited by J. C. Brash. London, Oxford University Press, 1902. Pp. 390–392.
4. HICKS, J. H.: The Mechanics of the Foot. I. The Joints. J. Anat., 87: 345–357, 1933.
5. KRAUSE, W.: Handbuch der Anatomie des Menschen. Leipzig, S. Hirzel, 1903. P. 99.
6. MANTER, J. T.: Movements of the Subtalar and Transverse Tarsal Joints. Anat. Rec., 80: 397–410, Aug. 1941.
7. ROSE, G. K.: Correction of the Pronated Foot. J. Bone Joint Surg., 44–B: 642–647, 1962.
8. WALKER, J. D.: [Relationship Between Flat Foot and the Talocalcaneal Joint]. June 1952. Unpublished report.